

PROGRESS REPORT ON THE PONDEROSA PINE  
THINNING STUDY, BANNOCK CREEK  
1934-1959

4/26/62

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Diameter Growth

I ran a Randomized Block Design on the diameter growth from 1934-1959 on the 20 selected crop trees. The results show a significant difference between no thinning and thinning but there were no differences between various degrees of thinning. The orthogonal comparisons show the specific relationships. No difference between degrees of thinning would be expected under these conditions, I think, because each tree was released individually and the entire stand is not concerned.

Cubic Feet Volume

I ran a covariance analysis on the crop tree cu. ft. vol. The results show no significant affect of thinning on volume production by covariance. However, if you analyze this by straight analysis of variance you get significant influence of thinning on volume. This means that the original volume has influenced the final volume, as we would expect. In other words, releasing trees every 20' was not sufficient to produce the desired volume. Covariance would probably mean more if it were applied to total stand volume. This way it would remove the affect of original stand stocking.

I started to test the percent normality but decided my assumptions were too weak.

/s/ Don (d) Hook (r)

Assumptions  
 1934 - age 20 yrs.  
 1959 - age 45 yrs.  
 Site Index 70

Thinned 1934

Measured 1959

| Age<br>when<br>thinned | Degree<br>of<br>thinning | Average D.B.H.    |                     | Basal area<br>average/acre |                       | Cubic foot<br>vol./acre |                       | Cu.ft.vol.<br>percentage<br>increase |
|------------------------|--------------------------|-------------------|---------------------|----------------------------|-----------------------|-------------------------|-----------------------|--------------------------------------|
|                        |                          | After<br>thinning | Average<br>increase | After<br>thinning          | Periodic<br>increment | After<br>thinning       | Periodic<br>increment |                                      |
|                        |                          | 20 Crop Trees     |                     | Crop Trees                 |                       |                         |                       |                                      |
| 20                     | None                     | 2.962             | 1.800               | 19.7                       | 24.2                  | 241.0                   | 740.4                 | 307                                  |
| 20                     | 10' con.                 | 3.195             | 3.170               | 20.2                       | 45.6                  | 290.8                   | 1379.2                | 474                                  |
| 20                     | 10' crop                 | 2.676             | 3.035               | 16.6                       | 38.3                  | 203.2                   | 1020.6                | 526                                  |
| 20                     | 15' crop                 | 3.142             | 3.417               | 17.6                       | 42.4                  | 243.2                   | 1360.4                | 559                                  |
| 20                     | 20' crop                 | 2.537             | 2.945               | 6.0                        | 15.1                  | 67.9                    | 439.5                 | 647                                  |
|                        |                          |                   |                     | Remaining Stand            |                       |                         |                       |                                      |
| 20                     | None                     |                   |                     | 44.0                       | 40.9                  | 356.4                   | 1031.2                | 289                                  |
| 20                     | 10' con.                 |                   |                     | --                         | --                    | --                      | --                    |                                      |
| 20                     | 10' crop                 |                   |                     | 2.2                        | 11.8                  | 10.6                    | 137.0                 | 1173                                 |
| 20                     | 15' crop                 |                   |                     | 10.3                       | 24.1                  | 72.8                    | 433.8                 | 596                                  |
| 20                     | 20' crop                 |                   |                     | 19.8                       | 48.2                  | 141.9                   | 927.4                 | 653                                  |
|                        |                          |                   |                     | Total Stand                |                       |                         |                       |                                      |
| 20                     |                          |                   |                     | 63.74                      | 65.2                  | 597.4                   | 1770.6                | 296                                  |
| 20                     |                          |                   |                     | 22.2                       | 45.6                  | 290.8                   | 1379.2                | 474                                  |
| 20                     |                          |                   |                     | 18.8                       | 50.1                  | 216.8                   | 1216.6                | 561                                  |
| 20                     |                          |                   |                     | 28.0                       | 66.4                  | 315.8                   | 1794.2                | 568                                  |
| 20                     |                          |                   |                     | 25.8                       | 63.5                  | 209.8                   | 1367.0                | 651                                  |

COVARIANCE ANALYSIS OF CROP TREES (Cubic foot volume)

x = Volume 1934

y = Volume 1959

| Trt          | Replications |        |       |        |       |        |       |        |       |        |        |          |
|--------------|--------------|--------|-------|--------|-------|--------|-------|--------|-------|--------|--------|----------|
|              | A            |        | B     |        | C     |        | D     |        | E     |        | Total  |          |
|              | x            | y      | x     | y      | x     | y      | x     | y      | x     | y      | x      | y        |
| Check        | 209.3        | 842.4  | 45.2  | 208.1  | 50.5  | 296.0  | 182.0 | 757.9  | 115.8 | 359.1  | 602.8  | 2463.5   |
| 10'conv      | 380.4        | 1563.8 | 114.5 | 580.6  | 52.3  | 689.3  | 151.7 | 1101.0 | 28.4  | 240.4  | 727.3  | 4175.1   |
| 10'crop      | 347.5        | 1541.6 | 15.6  | 165.9  | 51.5  | 511.2  | 24.0  | 248.7  | 74.7  | 747.1  | 513.3  | 3214.5   |
| 15'crop      | 294.9        | 1764.7 | 37.8  | 465.3  | 57.2  | 394.4  | 87.0  | 814.0  | 131.3 | 570.8  | 608.2  | 4009.2   |
| 20'crop      | 35.4         | 260.0  | 8.1   | 61.5   | 21.1  | 173.3  | 73.7  | 499.3  | 31.4  | 274.6  | 169.7  | 1268.7   |
| Block totals | 1267.5       | 5972.5 | 221.2 | 1481.4 | 232.6 | 2064.2 | 518.4 | 3420.9 | 381.6 | 2192.0 | 2621.3 | 15,131.0 |

$$\sum x^2 = (209.3)^2 + \dots + (31.4)^2 - \frac{(2621.3)^2}{25}$$

$$= 533767.53 - 274848.54 = \underline{258,919.99}$$

$$R_{xx} = \frac{2123,945.57}{5} - 274,848.54 = \underline{149,940.57}$$

$$T_{xx} = \frac{1,554,515.35}{5} - 274,848.54 = \underline{36,054.53}$$

$$E_{xx} = 258,919.99 - 149,940.57 - 36,054.53 = \underline{72,896.89}$$

$$\sum y^2 = (842.4)^2 + \dots + (274.6)^2 - \frac{(15,131)^2}{25}$$

$$= 14,260,064.92 - 9,157,886.44 = \underline{5,102,178.48}$$

$$R_{yy} = \frac{(5972.5)^2 + \dots + (2192.0)^2}{5} - \frac{15,131}{25}$$

$$= 11,726,728.93 - 9,157,886.44 = \underline{2,568,842.49}$$

$$T_{yy} = \frac{(2463.5)^2 + \dots + (1268.7)^2}{5} - 9,157,886.44 = \underline{1,145,430.93}$$

$$E_{yy} = 5,102,178.48 - 2,568,842.49 - 1,145,430.93 = \underline{1,387,905.06}$$

$$E_{xy} = (209.3)(842.4) + \dots + (31.4)(274.6) - \frac{(2621.3)(15,131.00)}{25}$$

$$= 2,644,810.32 - 1,586,515.61 = \underline{1,058,294.71}$$

$$R_{xy} = \frac{(1267.5)(5972.5) + \dots + (381.6)(2192.0)}{5} - 1,586,515.61$$

$$= 2,197,564.82 - 1,586,515.61 = \underline{611,049.21}$$

$$T_{xy} = \frac{(602.8)(2463.5) + \dots + (169.7)(1268.7)}{5} - 1,586,515.61 = \underline{178,533.33}$$

$$E_{xy} = 1,058,294.71 - 611,049.21 - 178,533.33 = \underline{268,712.17}$$

# COVARIANCE OF CUBIC FOOT VOLUME FOR CROP TREES

## Analysis of covariance

| Source of variance                           | d.f. | Sum of squares and products |            |              | Dev. about regression                     |      |             |
|----------------------------------------------|------|-----------------------------|------------|--------------|-------------------------------------------|------|-------------|
|                                              |      | $\sum x^2$                  | $\sum xy$  | $\sum y^2$   | $\sum y^2 - \frac{(\sum xy)^2}{\sum x^2}$ | d.f. | Mean square |
| Replicates                                   | 4    | 149,940.57                  | 611,049.21 | 2,568,842.49 |                                           |      |             |
| Treatments                                   | 4    | 36,054.53                   | 178,533.33 | 1,145,430.93 |                                           |      |             |
| Error                                        | 16   | 72,896.89                   | 268,712.17 | 1,387,905.06 | 397,421.79                                | 15   | 26,494.79   |
| Treatment & error                            | 20   | 108,951.42                  | 447,245.50 | 2,533,335.99 | 698,211.59                                | 19   |             |
| Diff. for testing among adj. treatment means |      |                             |            |              | 300,789.80                                | 4    | 75,197.45   |

Individual analysis of x and y

$$x \text{ trt.} = 9,013.63$$

$$\text{error} = 4,556.06$$

$$F = \underline{\underline{1.98}}$$

$$y \text{ trt.} = 286,357.73$$

$$\text{error} = 86,744.07$$

$$F = \underline{\underline{3.30^{*05}}}$$

$$F = \frac{75,197.45}{26,494.79} = \underline{\underline{2.84}}$$

$$\text{Reps.} = \frac{37,485.14}{4,556.06} = 8.23^{**}$$

$$\text{Reps.} = \frac{642,210.62}{86,744.07} = 7.40^{**}$$

## RANDOMIZED BLOCK DESIGN

Average D.B.H. Growth

| Trts | Blocks |        |        |        |        |        |
|------|--------|--------|--------|--------|--------|--------|
|      | A      | B      | C      | D      | E      |        |
| 1    | 1.963  | 1.333  | 1.866  | 1.478  | 2.026  | 8.666  |
| 2    | 3.480  | 2.822  | 3.036  | 4.050  | 1.950  | 15.338 |
| 3    | 3.730  | 2.353  | 3.340  | 2.640  | 2.850  | 14.913 |
| 4    | 4.355  | 4.200  | 2.572  | 3.750  | 1.687  | 16.564 |
| 5    | 3.420  | 2.226  | 2.450  | 3.180  | 2.989  | 14.265 |
|      | 16.948 | 12.934 | 13.264 | 15.098 | 11.502 | 69.746 |

$$C = \frac{(69.746)^2}{25} = \frac{4864.50}{25} = 194.58$$

$$\text{Total} = \frac{(1.963)^2 + \dots + (2.989)^2}{5} - C = 212.42 - 194.58 = 17.84$$

$$\text{Trt.} = \frac{(8.666)^2 + \dots + (14.265)^2}{5} - C = \frac{1010.61}{5} - 194.58 = 202.12 - 194.58 = 7.54$$

$$\text{Reps.} = \frac{(16.948) + \dots + (11.502)^2}{5} - 194.58 = \frac{990.70}{5} - 194.58 = 3.56$$

## A. O. V.

| Source | d.f. | S.S.  | M.S. | F         |
|--------|------|-------|------|-----------|
| Trt.   | 4    | 7.54  | 1.88 | 4.48* .05 |
| Reps.  | 4    | 3.56  | 0.89 | 2.11      |
| Error  | 16   | 6.74  | 0.42 |           |
| Total  | 24   | 17.84 |      |           |

Orthogonal comparisons:      S.S.

Check vs. thinning              = 6.98

10' conv. vs. all crop          = 0.001

10' crop vs. 15' & 20' crop = 0.033

15' crop vs. 20' crop          = 0.529

A.O.V. of treatments

| Source                      | d.f. | S.S.  | M.S.  | F       |
|-----------------------------|------|-------|-------|---------|
| Check vs. thinning          | 1    | 6.980 | 6.980 | 16.62** |
| 10' con. vs. crop           | 1    | .001  | .001  | .002    |
| 10' crop vs. 15' & 20' crop | 1    | .033  | .033  | .078    |
| 15' crop vs. 20' crop       | 1    | .529  | .529  | 1.259   |
| Error                       | 16   | 6.74  | 0.42  |         |

|       | 1  | 2  | 3  | 4  | 5  |     |
|-------|----|----|----|----|----|-----|
| $C_1$ | -4 | +1 | +1 | +1 | +1 | = 0 |
| $C_2$ | 0  | -3 | +1 | +1 | +1 | = 0 |
| $C_3$ | 0  | 0  | -2 | +1 | +1 |     |
|       | 0  | 0  | 0  | -1 | +1 |     |